

Bio-Compatibility of Zirconia (ZrO_2) Ceramic Thin Films

S. Sakthivel, D. Saritha and V. Baskaran

Thin film Physics and Nano Science Laboratory,
PG and Research Department of Physics,
Rajah Serfoji Govt., College (Autonomous),
Thanjavur, Tamilnadu, INDIA.

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ABSTRACT

Zirconia ceramics are bio-inert materials that are compatible for biomedical field in deployment as implants for humans. The different concentration of Zirconia thin films were examined by Sol-gel technique. The class of ceramics used for repair and replacement of diseased and damaged parts of musculoskeletal systems are termed bio- ceramics. Bio-ceramics range bio-compatibility from the ceramic oxides which are inert in the body, to the extreme of resorbable materials which are replaced by the materials which they are used to repair. Bio-inert high strength materials do not release any toxic constituents, they do not show positive interaction with living tissue. The deposited films were subjected to X-ray diffraction (XRD), Scanning Electron Microscopy (SEM). The mechanical behaviour of bio-inert Zirconia ceramic thin films shows that bio-compatibility of material.

Keywords: Alumina, Bio ceramics, spray pyrolysis, mechanical properties, Bio-inert.

1. INTRODUCTION

The challenge for the materials scientists is to develop new ceramics that produce the most appropriate response that the clinical situation demands. It has been accepted that no foreign material placed

within a living body is completely compatible. The only substances that conform completely are those manufactured by the body itself. No synthetic material can be considered as being inert as all materials will produce some sort of a response from living tissue. These materials will be

recognized as foreign and may initiate any of a range of tissue responses. Bio ceramics are an important subset of bio materials¹. The class of ceramics used for repair and replacement of diseased and damaged parts of musculoskeletal systems are termed bio ceramics². Bio ceramics range in biocompatibility from the ceramic oxides, which are inert in the body, to the other extreme of resorbable materials by which are eventually replaced by the materials which they are used to repair. Bio ceramics are now used in a number of different applications throughout the body. They are usually used to replace hard tissue in the body like bone and teeth³. Bio inert materials do not release any toxic constituents but also do not show positive interaction with living tissue.

In the present work, we first utilized the preparation of Zirconia bio ceramics using thin film techniques and their biocompatibility, mechanical properties and applications are also discussed. However, there is a growing trend toward bio materials that are designed to produce a well-defined interaction with the biological environment, one obvious example being the bioactive glasses, which stimulate the formation of new bone⁴⁻⁶.

2. EXPERIMENTAL DETAILS

2.1 Preparation of Zirconia Ceramics

Thin films of Zirconia (ZrO_2) Ceramics were obtained using the sol-gel deposition technique from an aqueous solution. Zirconia (ZrO_2) and deionized water were used as precursor solution⁷. Using a hot plate the substrates were heated at the deposition temperature. This

processing route consists of the above mentioned 8 M Zirconia powder in absolute ethanol and distilled water with the volume ratio 1:3. Sol – gel was formed after being stirred at room temperature for ten minutes. The substrate was dipped in the solution for 24 hours. A thin coating with white Coloration appeared on the substrate. The coated substrate was removed at the end of deposition. After deposition, the films were thermally treated at 850°C for 2hr in order to remove organic residuals. The mechanical behaviour of the sample was studied for metal rod shape materials. The rod was prepared by injecting alumina solution into metal cylindrical / rectangular rod. The metal rod was heated at 700°C , and then the rod was cooled to room temperature gradually.

2.2. Material Characteristics

Zirconia (ZrO_2) is also a white powder. Like alumina, it can be compressed and sintered into a very strong ceramic. Unlike alumina, its wear-resistance properties are not as good. Zirconia bio ceramics do not have the high wear resistance of alumina bio ceramics and are not as widely used in hip joint applications. Zirconia is a biomaterial that has a bright future because of its high mechanical strength and fracture toughness⁸. Zirconia ceramics have several advantages over other ceramic materials due to the transformation toughening mechanisms operating in the microstructure that can be manifested in components made out of them. Zirconia toughened alumina have both the properties alumina and Zirconia and its used for joint prosthesis. However, their fracture toughness and bending strength give them

additional qualities. We examined the Zirconia ceramic rods with 174.449 young's modulus [GPa] was obtained and it also very close to the reported values.

3. RESULTS AND DISCUSSION

3.1 XRD Analysis

XRD patterns of prepared Zirconia Ceramics (ZrO_2) thin films on glass substrate were shown in Figure 1. These XRD patterns show that prepared ZrO_2 has a

tetragonal crystal structure. In Figure 1, the intensities of the Peaks attributed to (011), (002), (110), (012), (112), (020), (121), (202) and (004) of ZrO_2 appeared, which can be confirmed by the Powder Diffraction File (PDF) JCPDS #50-1089. Moreover, the intensity of the (011) and (002) is the strongest, indicating that the sample corresponds to the primitive lattice structure which belongs to the tetragonal system. The XRD patterns of thin film samples indicated that not only the highly oriented and it has polycrystalline nature.

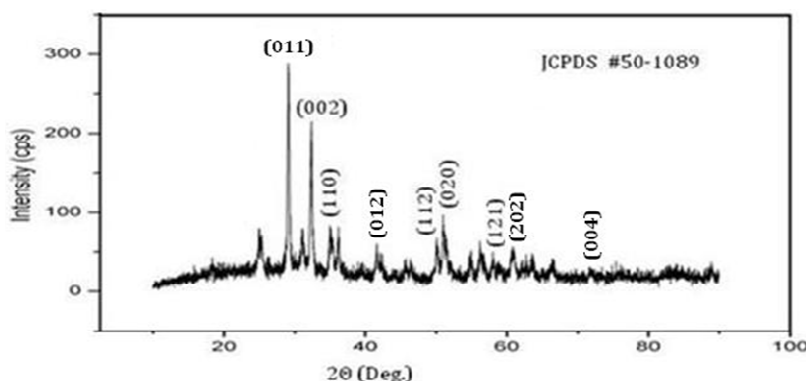


Fig.1. X-ray diffractogram Zirconia bio ceramic thin film by Sol-gel method

3.2 Morphological analysis

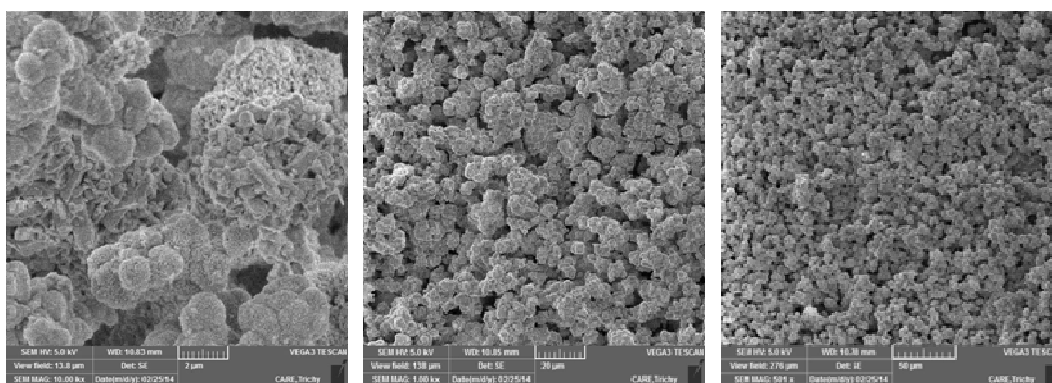


Figure 2: The SEM image of the ceramic Zirconia bio ceramic thin film (a) 2 μm (b) 20 μm (c) 50 μm

Fig. 2 (a-c) shows the scanning electron microscope (SEM) image of ZrO_2 . Powder/ film coated on well cleaned optically plane glass plate. Fig.2 gives information about powder/film on glass almost uniform particle size distributed throughout the glass plate enlarged at 2 μm , 20 μm and 20 μm ranges. The density of the material more at the center left to right of the SEM picture. But at the top and bottom of the picture gives comparatively less density. For the focusing of close to 50 μm and 20 μm SEM images representing confining the uniform particle size and uniform distribution. Fig.2 (a - c) shows ZrO_2 ceramic film formation with cluster of grains forming big particle of size at 500nm.

4. CONCLUSIONS

Bio-inert ZrO_2 ceramic materials that is compatible for biomedical field in deployment as implants for humans. X- ray diffraction spectrum of ZrO_2 shows a polycrystalline in nature. Average grain size of ZrO_2 ceramic was obtained 22 - 46 nm. Scanning electron microscope of ZrO_2 gives a surface morphology was helpful to design the bio-structure. The measured Young's Modulus value of the Zirconia bio ceramic was 174.449 GPa have highly matched with standard value. The ZrO_2 ceramic films with cluster of grains are combined together and forming the big particles of size about 450 nm-1850 nm. Surface morphology of the ZrO_2 ceramic makes it useful in orthopaedic applications. The analyses of the results from the cantilever method ZrO_2 ceramic have high mechanical strength. Zirconia is a biomaterial that has a bright future because of its high mechanical strength and fracture toughness. Zirconia-based ceramics has been

increasingly used as implant biomaterials. It is used as biomaterial has some limitation such as fatigue failure.

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